MSK Trauma: Imaging Essentials and Language of Fractures

Les Folio, DO, MPH
Col, USAF, MC, SFS
lfolio@usuhs.mil
Assistant Professor, Radiology and Radiological Sciences
MS-4 Radiology Clerkship Director
Assistant Chair for Military Radiology
Uniformed Services University of the Health Sciences

Announcements

- MS 4 radiology elective specifics:
  - Plenty of availability in the classes (up to 20 ea)
    - Somewhat more crowded in first two blocks, however, rarely turn a student down
    - Sign up with Janice Merrick in Dept of radiology
    - Audience Response System, new comprehensive syllabus
    - One week clinical for solidifying the didactics
- Radiology Interest Group
  - Open to all students (radiology interest or other)
    - Had successful meeting weeks ago about residencies
  - More information contact RIG president:
    - Steven Craig at s8scraig@usuhs.mil

Overview, Objectives

Systematic Approach

I dentify the abnormality (*Recognize* injury)
D efine the appearance (be descriptive)

C ategorize (when able); patterns, grades
D ifferential Diagnosis

(ABCDE'S)^2 in MSK Imaging

Examples
Descriptive terms, considerations
Adults, pediatrics
SALTER

Findings to recognize

*** = Things you (and your patient) don't want to miss**
Some are subtle, some invisible (only secondary signs)
Some seemingly trivial trauma and findings can result in permanent disability

Summary

Approach
*** = need to know to recognize**
Mnemonics
Overview
Questions

References

Overview

Recognize the Injury * MUST

Radiograph where it hurts or where it is deformed

Overview

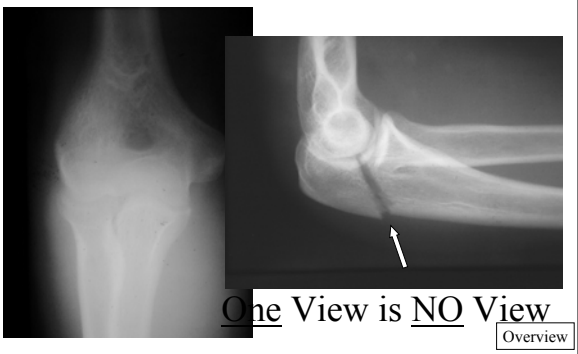
* Key Findings To Recognize

- Cases throughout that are used as example
- Need to recognize as intern, GMO, Flight doc
  - No time to look up, cannot afford to miss
  - Missing could end up with permanent deformity
- Must refer, at least until comfortable with dx, tx

Overview

Recognize the Injury: * MUST

Two Orthogonal Views at a Minimum

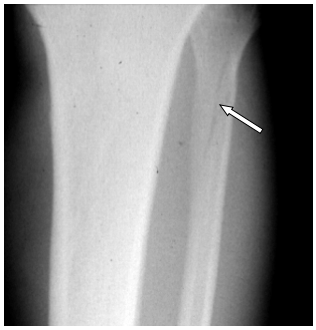


One View is NO View

Overview

Recognize the Injury: * MUST

Long Bones: Need to See the Joints at Both Ends



Overview

Back to the Basics: Systematic Approach

- CPR, ACLS, ATLS: ABCDE's
  - Airway, Breathing, Circulation
    - Disability (neuro, AVPU), Extremities
    - However, cervical spine stabilized before Airway
      - i.e. jaw-thrust in unconscious or suspected injury
  - Evaluate extremities after stabilizing ABC's
  - $(ABCDE'S)^2$ in MSK Imaging
- Radiologic triage: prioritize multiple cases

Approach

*$(ABCDE'S)^2$ in MSK Imaging

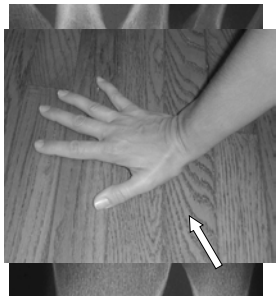
A = Anatomic appearance	A = Alignment, Asymmetry
B = Bone Density	B = Bone mineralization
C = Cartilage (joint, disk spaces)	C = Contours, Characteristics
D = Distribution	D = Deformity (trauma, acquired)
E = Erosions	E = Extent
S = Soft tissues	S = Swelling

"Checklist"

MedPix Factoid 6900:
http://rad.usuhs.mil/medpix/medpix.html?mode=single&recnum=6900

Approach

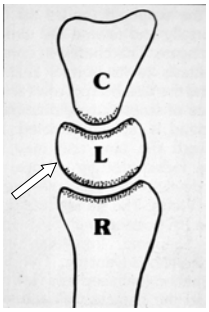
"A" Anatomic Appearance



*

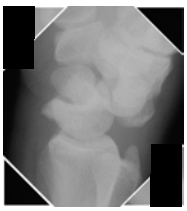
$(ABCDE'S)^2$

"A" Anatomic Appearance



*

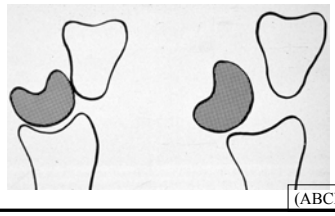
$(ABCDE'S)^2$



Normal

Perilunate Dislocation

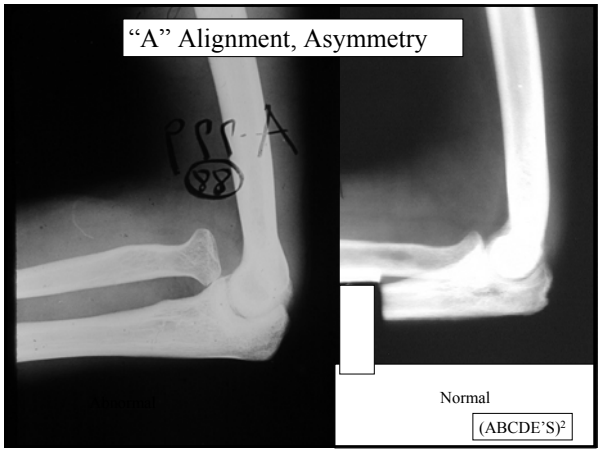
Lunate Dislocation



*

$(ABCDE'S)^2$

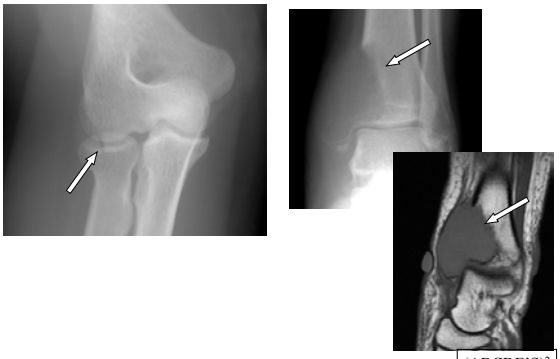
"A" Alignment, Asymmetry



Normal

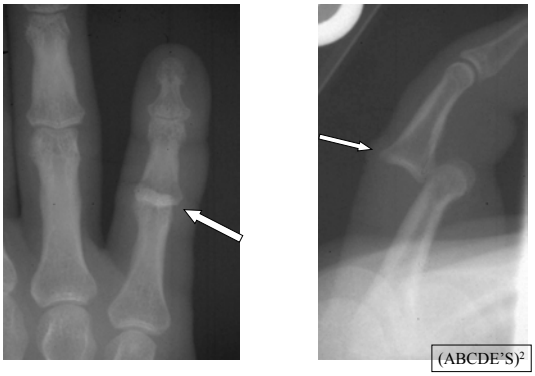
(ABCDE'S)²

"B" Bony Mineralization (or lack of), Bone Density



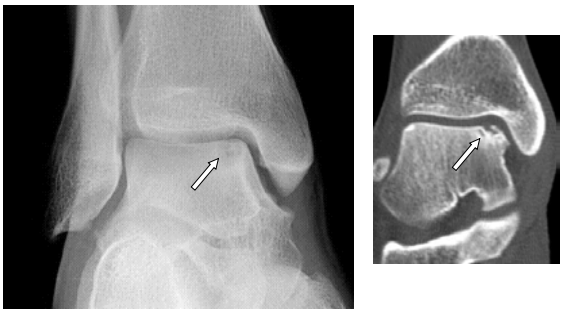
(ABCDE'S)²

"C" Cartilage "Joint Space"



(ABCDE'S)²

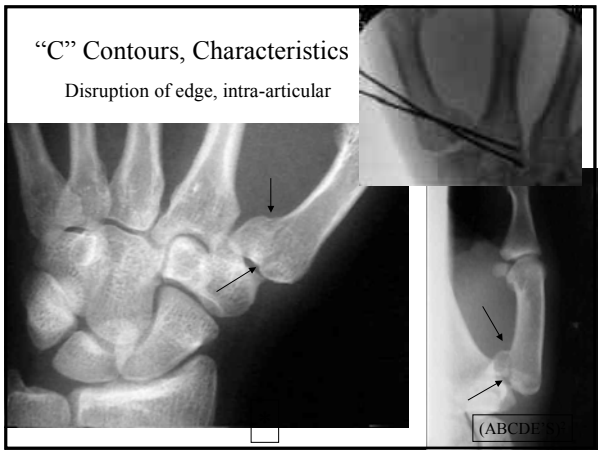
"C" Cartilage "Joint Space"



(ABCDE'S)²

"C" Contours, Characteristics

Disruption of edge, intra-articular



(ABCDE'S)²

"D" Deformity

- Chronic osteo
- MedPix 2697

Other considerations:
Congenital,
Post-traumatic

(ABCDE'S)²

Distribution

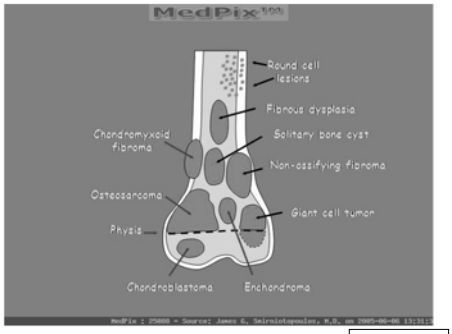
Multiple ribs with
various stages of healing
(Non-accidental trauma)

Other considera
- Mets
- Metabolic

*

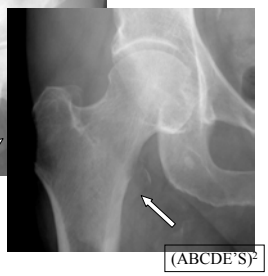
(ABCDE'S)²

"E" Erosions, Extent



(ABCDE'S)²

"E" Erosions, Extent



Pathologic fracture of Lesser Trochanter until proven otherwise

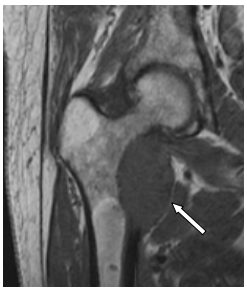
(ABCDE'S)²

Lesser Trochanter

Large lytic lesion in intertrochanteric region of femur

(ABCDE'S)²

Lesser Trochanter

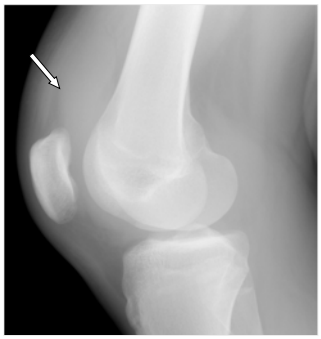


(ABCDE'S)²

"S" Soft Tissues

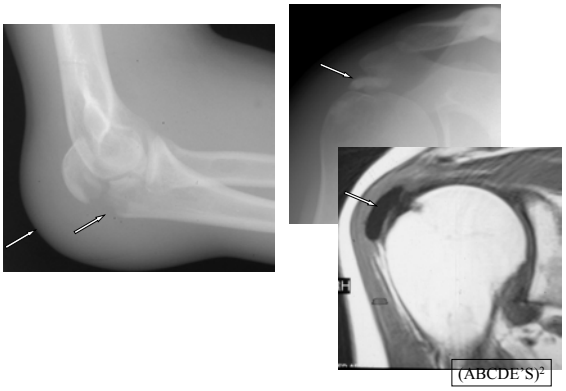
Joint effusion
= internal derangement

May get foreign bodies
US may help dx and tx



(ABCDE'S)²

"S" Swelling, Soft Tissues



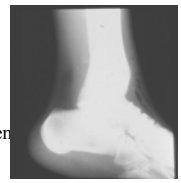
(ABCDE'S)²

Describing MSK Trauma

- Integrity of Skin
  - Open or Closed
- Severity of Fracture
  - Incomplete/Complete
  - Comminuted
- Fracture Line
  - Transverse, oblique, spiral
- Location
- Avulsion, distraction

- Separation/Overlap of Fragments
- Displacement
  - Alignment/Position
- Relationship to Joint/Growth Plate
- Integrity of Underlying Bone
  - Pathologic fracture

Integrity of Skin



- Open
  - Surgical emergency – washout/debridemen
  - Open fracture → open surgical reduction
  - Gas in soft tissues/bone thru skin
- Closed
  - Overlying skin intact
- Old terminology
  - Simple
  - Compound

Crush Injury to Distal Phalynx

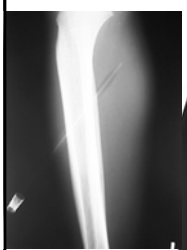
*

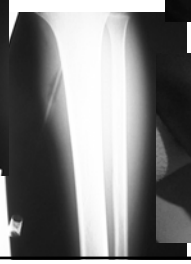
Even if skin is intact, if the nail bed is not intact: consider it an open fracture: antibiotics

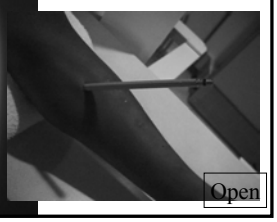
Open

Penetrating Injuries:

"Pencil-pusher"





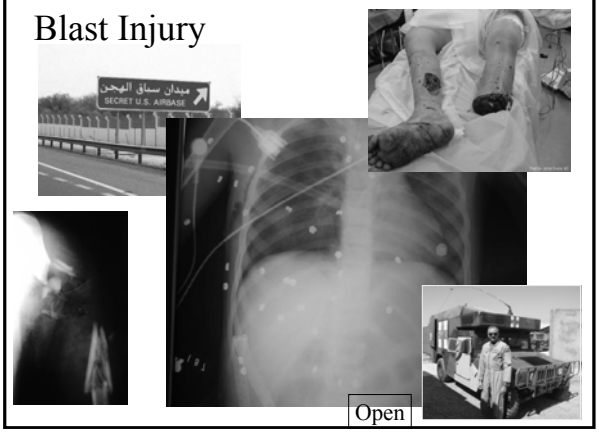


Open

Blast, shrapnel, RPG

Open

Blast Injury

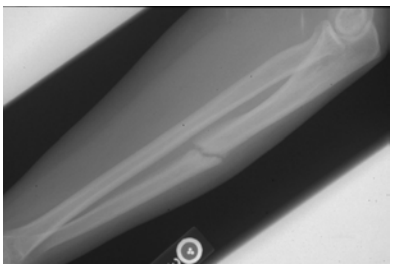


Open

Vascular Considerations

Fractures

- A <u>complete</u> or <u>incomplete</u> break in the continuity of bone or cartilage



Fractures

Severity of Fracture

- Complete – complete disruption of cortex
- Incomplete – only one side of cortex
  - Usually in children (Peds later in talk)
    - Greenstick – break on convex side
    - Torus – buckle
  - Adults:
    - Stress fx: abnormal stress to normal bone
    - Insufficiency: normal stress to abnormal bone

Fractures

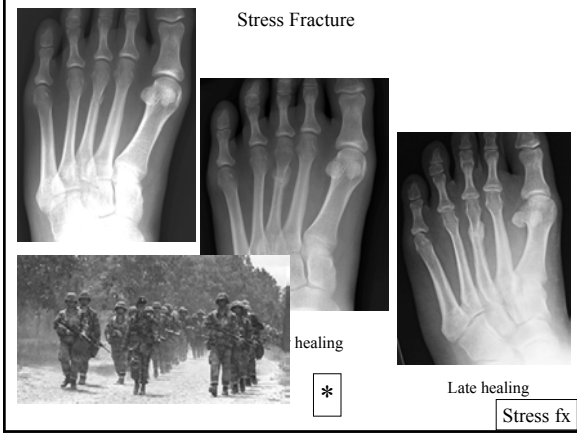
Complete Fracture

Fractures

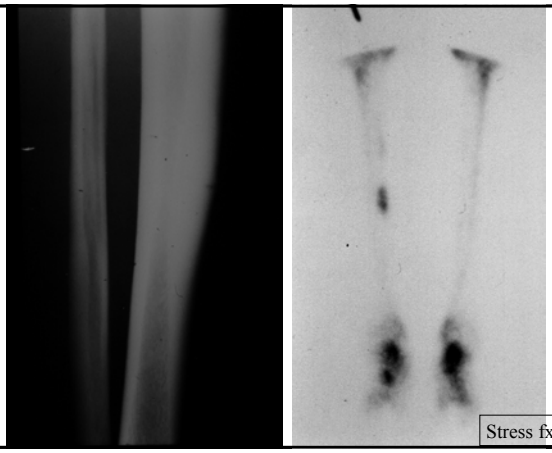
Stress Fracture

- Excess or abnormal stress applied to normal bone
- Resorption exceeds repair
- Bone scan or MR are more sensitive for detection of early stress fracture
- Insufficiency fracture
  - Normal stress to osteoporotic bone

Fractures

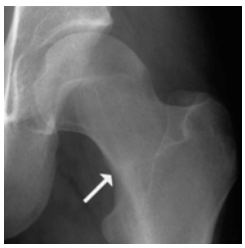


Stress fx



Stress fx

Stress Fracture of Hip

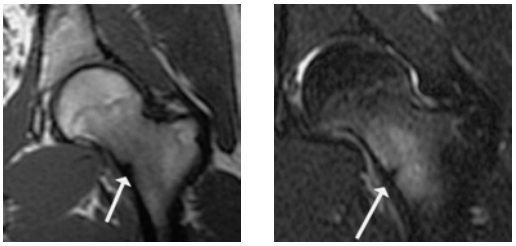


19 y.o. basic trainee presents with pain in left hip while running

-Plain film: demonstrates sclerotic line in femoral neck perpendicular to normal trabeculae

Stress fx

Stress Fracture of Hip



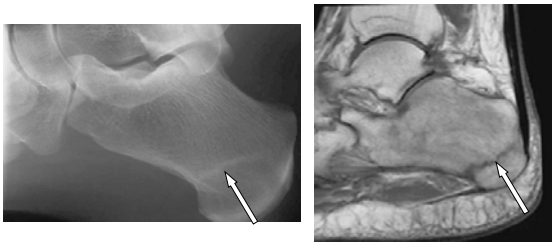
-MRI: demonstrates black line on all pulse sequences

-Line does not traverse entire width of femoral neck

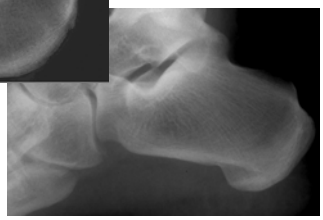
-Surrounding edema is present

Stress fx

Incomplete fracture in adult is usually a stress fracture



Stress fx

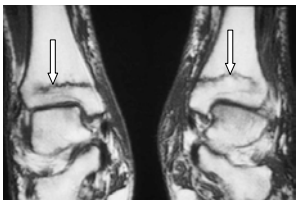


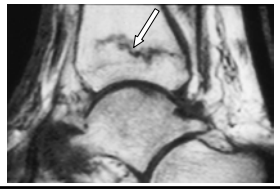
Ill-defined white line oriented perpendicular to the normal trabecular pattern

Normal trabecular pattern

Stress fx

Insufficiency Fractures





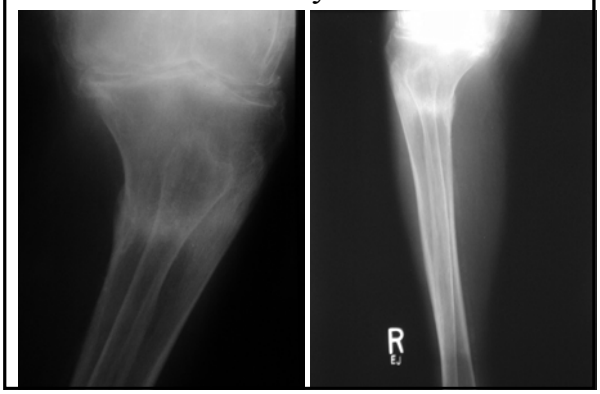
54 y.o. women with history of. breast carcinoma

On Tamoxifen

Bilateral ankle pain after trip to Hawaii

Normal stress to abnormal bone

Insufficiency Fracture



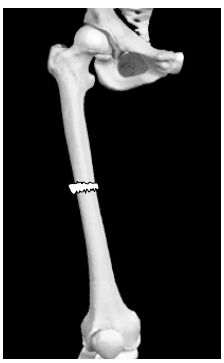
Fracture Line Orientation, Location

- Transverse
- Oblique
- Spiral

Location

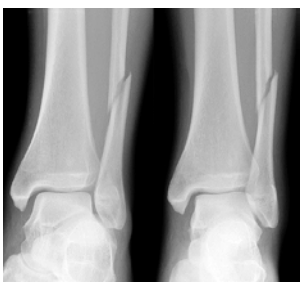
What 1/3?

Transverse



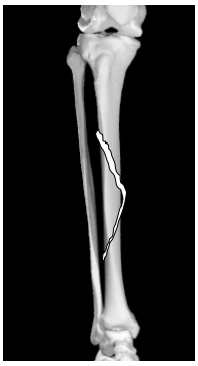
Orientation/ location

Oblique



Orientation/ location

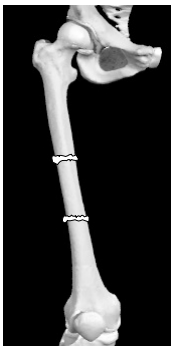
Spiral

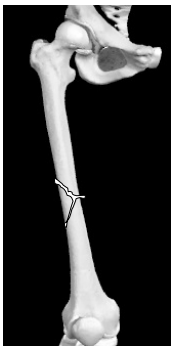


Orientation/ location

Comminuted Fracture

- More than two fragments
  - -- Segmental
  - -- Butterfly



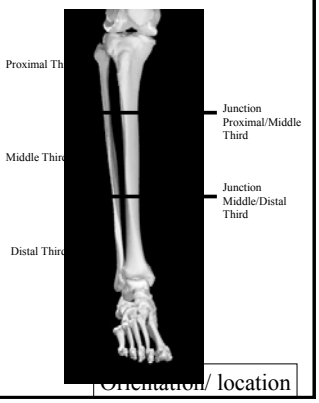


Orientation/ location

Orientation/ location

Location

- Long bones: divide diaphysis into thirds



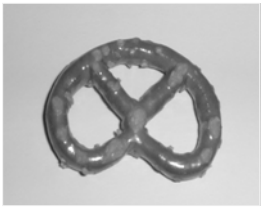
Orientation/ location

Location: Specific Anatomic Description

–Humeral head
–Tibial plateau
–Waist of scaphoid
–Femoral condyle
–Femoral neck
–Intertrochanteric

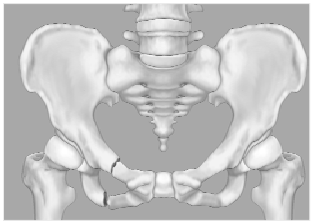
Orientation/ location

Fibro-osseous Rings

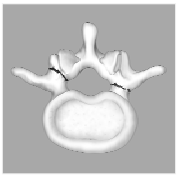


Simple or complex rings

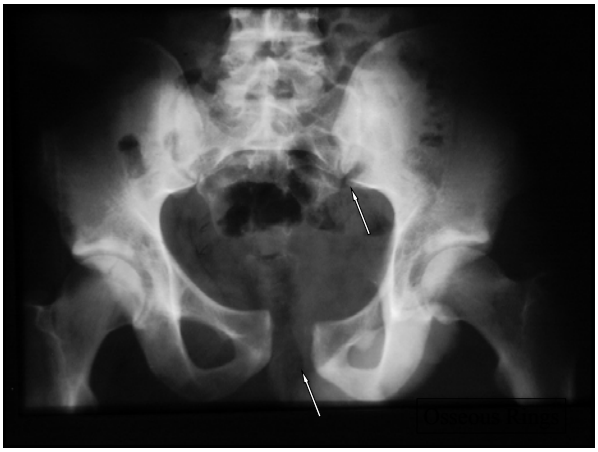
Osseous Rings



- Pelvis
- Mandible
- Radius/ulna
- Tibia/fibula
- Post elements spine, Atlas
- Orbit
- Maxillary Sinus



*



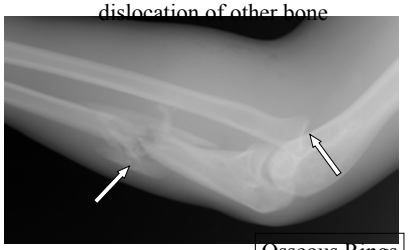
Osseous Rings

Ulna/Radius, Tibia/Fibula

Act Like Ringed Structures

-If one bone fractured

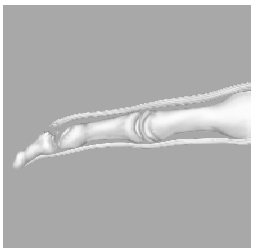
-Look for fracture or dislocation of other bone



Osseous Rings

Separation/Overlap of Fragments

- Distraction
  - Separation of fragments
    - Tendon
    - Traction
    - Interposed soft tissue



*

Mallet Finger

Sudden resisted flexion of DIP joint

Finger jammed or distal tip hit with a ball

Can result in permanent Swan-Neck deformity

especially if not properly diagnosed and/or treated

Separation/Overlap

Avulsion Fracture of Flexor Digitorum

*

Separation/Overlap

Overriding Fragments

- Describe in cm
- Transverse fx of middle 1/3 of radius with 2 cm overlap on AP

Separation/O

Impaction

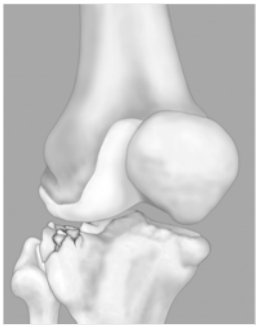
Fragments driven into each other

Depression

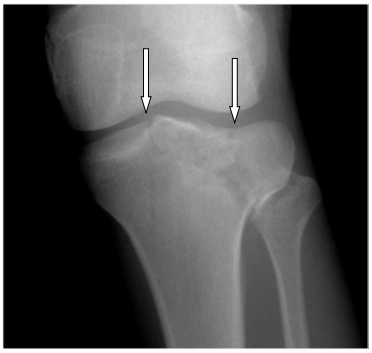
Cortical meets cancellous

Compression

Crushing of trabecular bone



Separation/Overlap

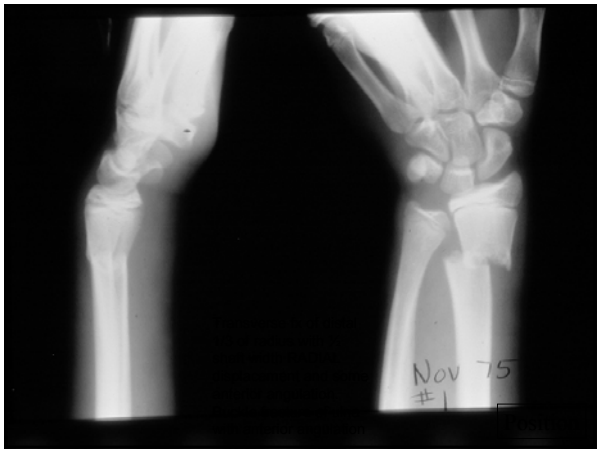


Impacted comminuted fracture of lateral tibial plateau with __ mm of downward displacement

Separation/Overlap

Position (Displacement)

- Description of fragments relative to normal
- Assume proximal fragment is normal
- Describe distal fragment relative to prox
  - Use shaft width as a guide
- Use terms anterior, posterior, medial or lateral



Angulation

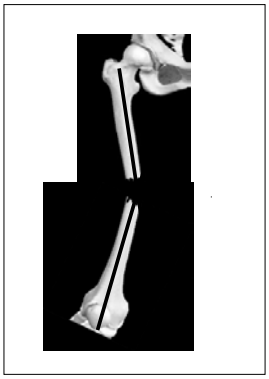
- Relation of long axes of one fragment to another
- Angulation is independent of displacement
- Assume proximal fragment is normal
- Describe direction of fracture apex

  or

- Describe direction distal fragment

Position

Fracture Description

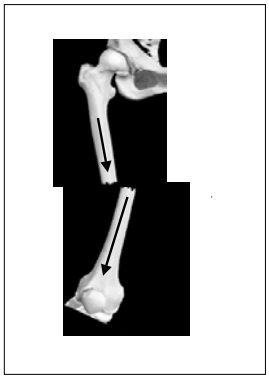


Angulation

1. Assume proximal fragment is normal
2. Draw the axes of the two fragments

Position

Fracture Description



Displacement

Quantify and give direction of displacement of distal fragment

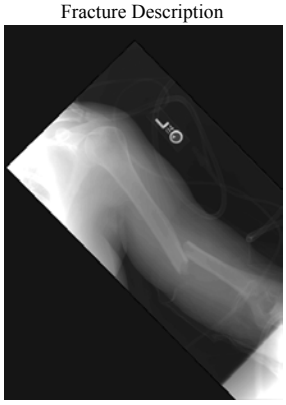
Use "shaft-width" to Quantify

-Distal fragment displaced 1 shaft-width medially

-Apex medial angulation

Position

Fracture Description



Distal fragment displaced 1 shaft-width laterally

20° of apex medial angulation at fracture site

1 cm of shortening (overlap) of fracture fragments

Position

Pathologic Fracture

- Integrity of underlying bone is abnormal
- Diagnosis may be benign or malignant
- History is often minimal trauma
  - When fractured, either pathologic or insufficiency

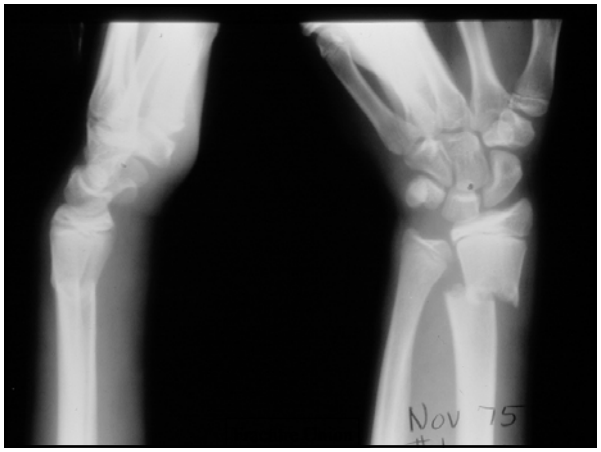
Pathologic Fracture

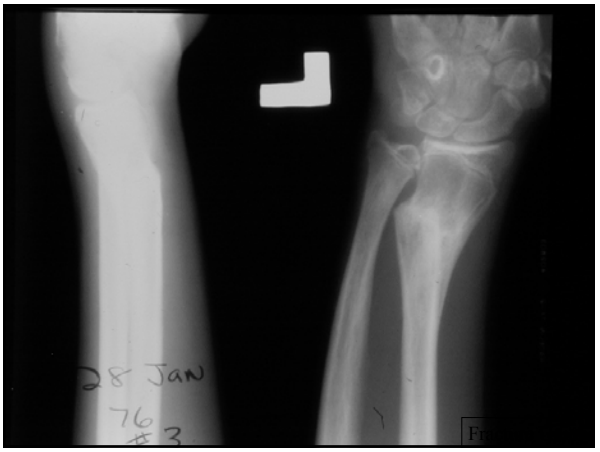
Expansile lucent area
Large, metaphyseal
Fallen fragment
Narrow transition zone
Simple bone cyst

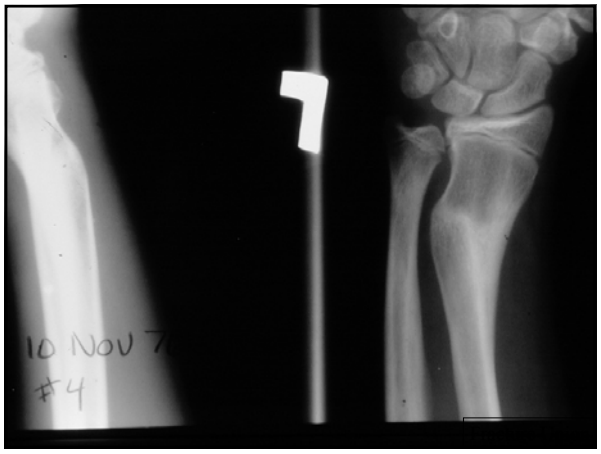
MedPix™

Fracture Union Terminology

- Callus – new bone formed at fracture site
- Remodeling – reforming of callus along lines of stress to approximate normal contour
- Delayed Union – Fracture fails to heal in usual time but will heal if cause of delayed healing is corrected



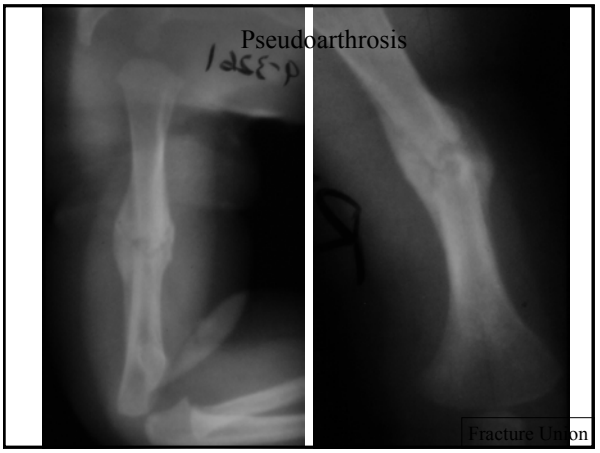




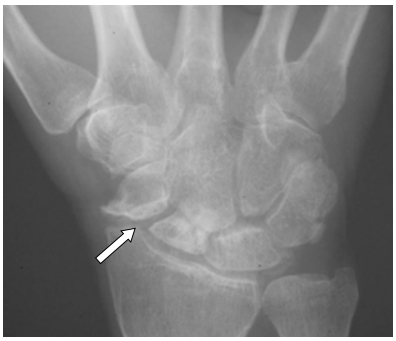
More Fracture Union Terminology

- Non-union – failure of fracture fragments to unite and healing process has stopped
- Pseudoarthrosis – Bursal sac and fibrous tissue that develops at site of non-union
- Malunion – fracture fragments have healed with angular or rotational deformity that impairs function

Fracture Union



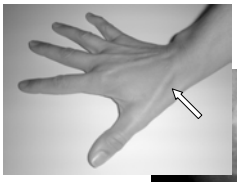
Nonunion of Scaphoid Fracture

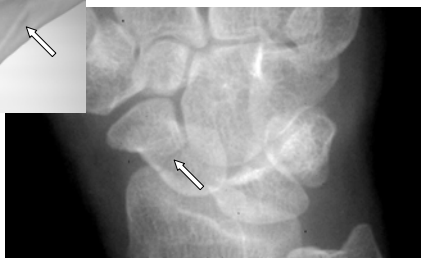


*

Fracture Union

Anatomic Snuff Box Tenderness





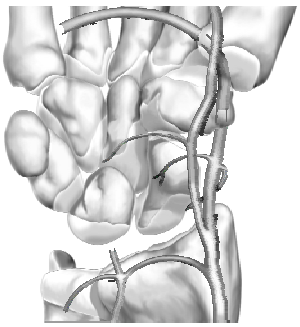
*

Scaphoid Fracture

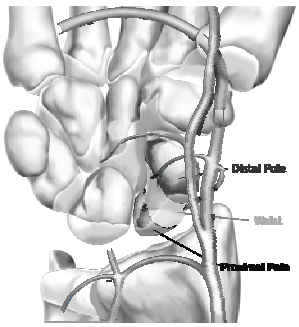
Scaphoid View: Ulnar Deviation

*

*



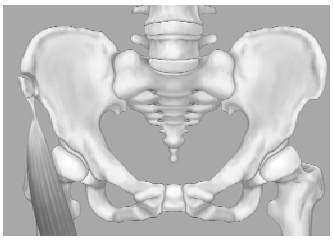
*



*

Avulsion Fracture

- Fracture involving the attachment site of a ligament or tendon insertion



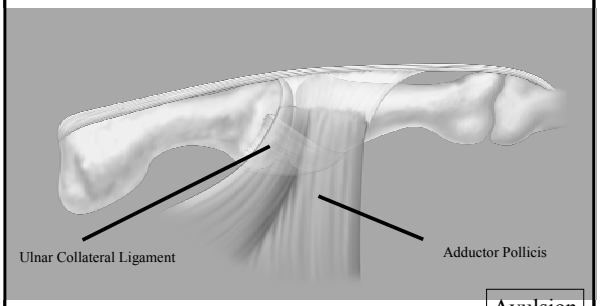
Skier's Thumb Injury

Disrupt Ulnar Collateral Ligament

*

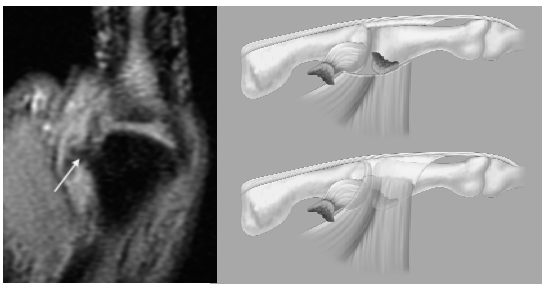
Avulsion

Anatomy: 1st Metacarpal Phalangeal Joint



Avulsion

Stener Lesion



-UCL: retract and displaces superficial to the adductor apponeurosis

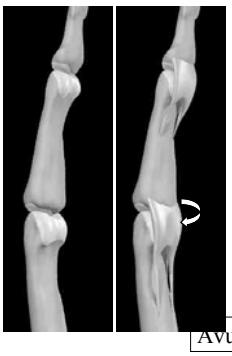
-Requires surgical repair: leads to instability and early arthrosis

Avulsion

*

Volar Plate Avulsion

-Hyperextension injury



Avulsion

Avulsion of Peroneus Brevis Tendon

Jones fracture more distal

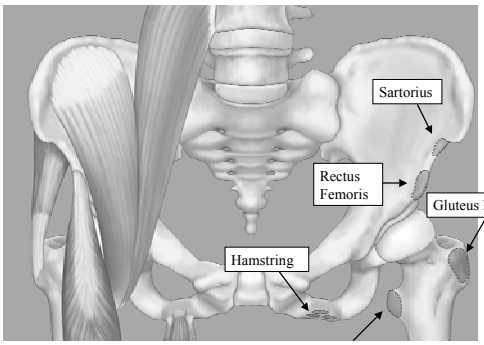
*

Apophyseal Avulsions

- Result from violent muscular contraction
- Typically seen in adolescent athletes
- Equivalent to a muscle pull in a mature athlete
- Sprinters, long jumpers, cheerleaders, hurdlers, gymnasts
- Pelvis: common location in adolescent runners

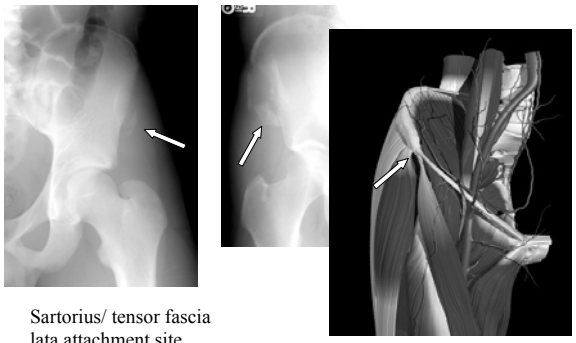
Avulsion

Tendon attachment sites



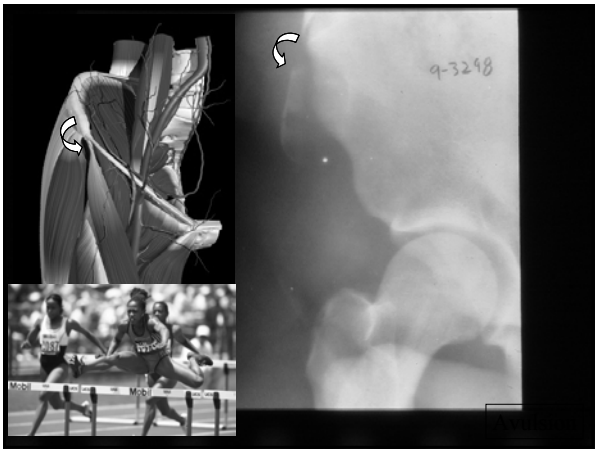
Avulsion

Anterior Superior Iliac Spine

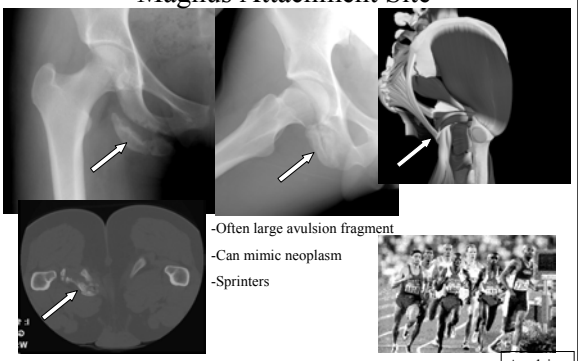


Sartorius/ tensor fascia lata attachment site

Avulsion



Ischial Tuberosity: Hamstring/ Adductor Magnus Attachment Site



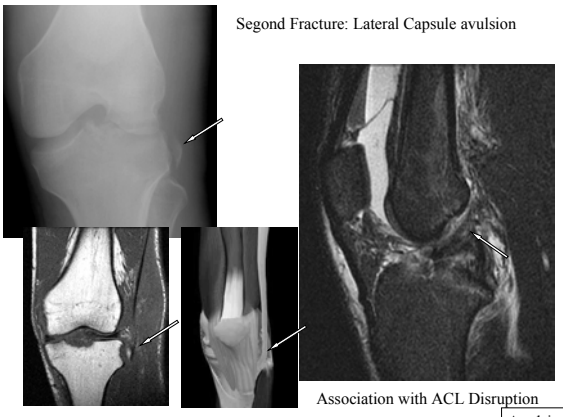
-Often large avulsion fragment

-Can mimic neoplasm

-Sprinters

Avulsion

Segond Fracture: Lateral Capsule avulsion

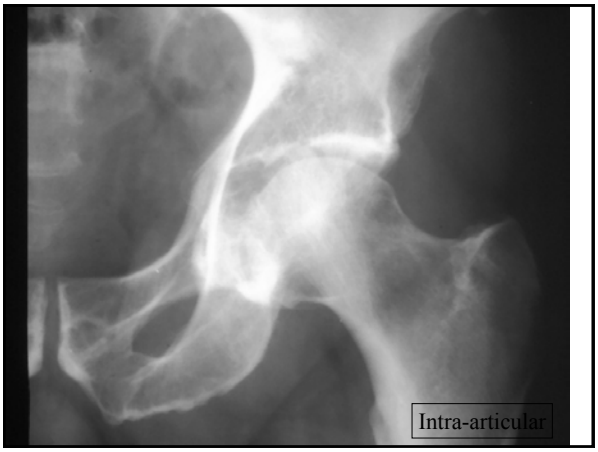


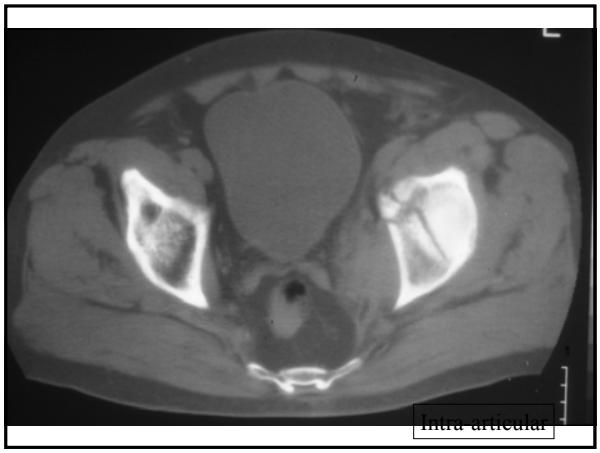
Association with ACL Disruption

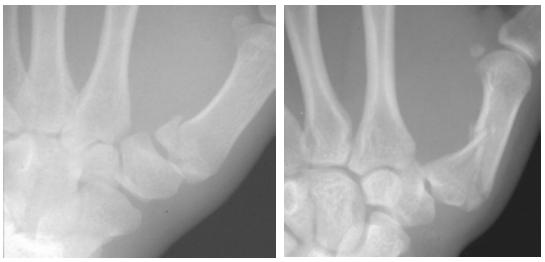
Avulsion

Intra-articular Fracture

- Fracture involves the joint surface of bone
- Often present with effusion
- Increased risk of post-traumatic osteoarthritis
- May involve bone and/or cartilage
- May require advanced imaging (CT or MR) to adequately characterize







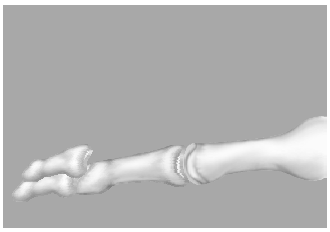
"Bennett" "Rolando"

"Bad" "Ruined"

*

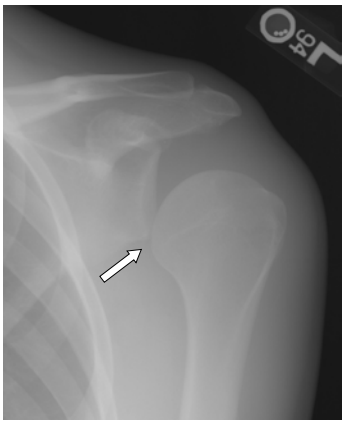
Intra-articular

Subluxation

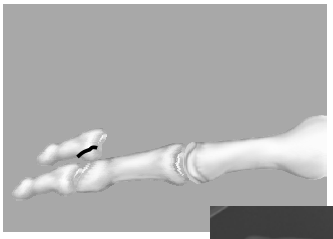


•Abnormal relationship between ends of a joint with some contact of the articular surfaces

•Incomplete dislocation



Dislocation



Complete separation of articular surfaces

May be associated with a fracture

–Fracture dislocation

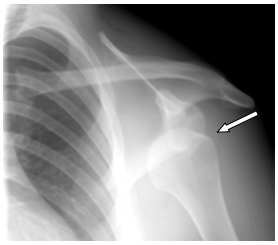
Dislocation

*

Normal

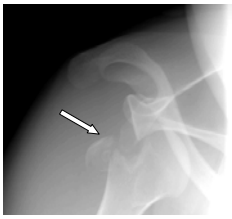
Anterior dislocation

Anterior Dislocation (majority of shoulder)



-Mechanism: fall on outstretched arm (or humerus)

-X-ray: humeral head displaced anterior and medial



Hill Sachs Lesion

-Occurs secondary to humeral head impaction against inferior glenoid rim

Dislocation:

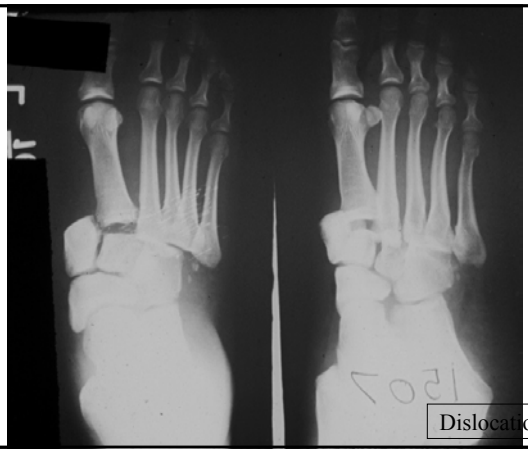
Posterior more common in hip

Dislocation

Posterior Elbow Dislocation

-Direction of dislocation determined by the position of the distal bones

Dislocation



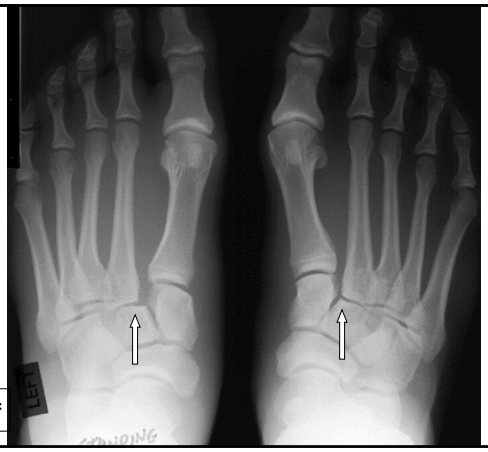
Dislocation

Normal Anatomy of the Lisfranc Joint

Alignment

Lisfranc Ligament

*



*

Diastasis

- Disruption of fibrocartilaginous joint
  - Pubic symphysis
  - Sacroiliac joint
  - Tibiofibular syndesmosis
  - Acromioclavicular joint

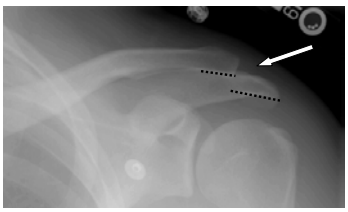
Acromio-clavicular Joint Injuries

-Mechanism: fall on outer prominence of shoulder

-Grade I injury- mild strain of AC joint

Diastasis

Acromio-clavicular Joint Injuries



-Grade II injury- moderate strain

*

Diastasis

Acromio-clavicular Joint Injuries

Grade III injury- severe

*

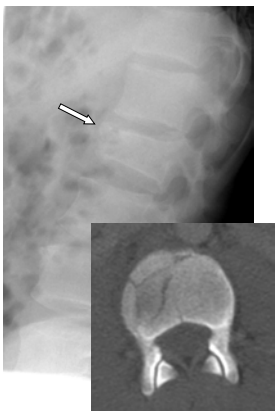
Diastasis

Distal Tib-Fib Joint

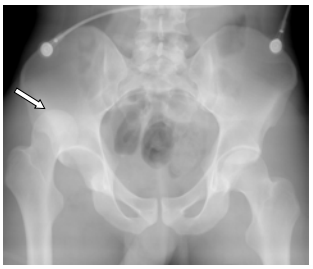
Diastasis

Diastasis

Lover's Heel



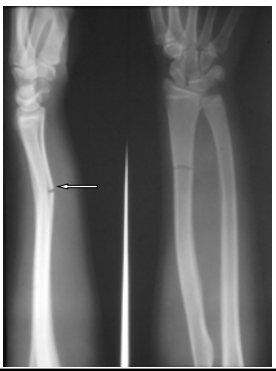
Dashboard Injury



Pediatric Injuries

- Injuries occur in different pattern in growing bone
  - Greenstick, torus, plastic fractures
- Injury to physeal plate
  - Growth arrest and limb length discrepancy
- Injuries tend to heal faster

Greenstick



-Bowing with fracture on convex side

*

Torus
"Buckle" Fracture

*

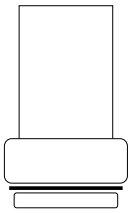
Salter-Harris classification
Mnemonic: usual orientation

I. S = Separation: Physis (growth plate)
II. A = Above epiphysis
III. L = Lower fragment: Physis/Epiphysis
IV. T = Through both
V. E = Epiphysis: Crushed Physis.
VI. R = Really bad (rare, perichondral)

http://rad.usuhs.mil/medpix/medpix.html?mode=single&recnum=4191&table=card&srchstr=salter%20harris&search=salter%20harris#top

*

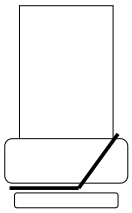
Salter Harris Fracture Classification



I – Through physeal plate
–May need comparison views to recognize "Separation"

SALTER

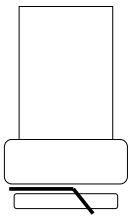
Salter Harris Fracture Classification



II – Physeal plate + metaphysis
–Most common
–"Above"

SALTER

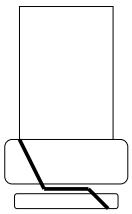
Salter Harris Fracture Classification



III – Physeal plate + epiphysis
"Lower"

SALTER

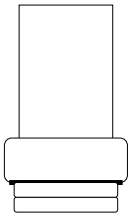
Salter Harris Fracture Classification



IV – Metaphysis, physeal plate, epiphysis
"Through both"

SALTER

Salter Harris Fracture Classification



V – Crush injury of physeal plate
"Epiphysis"

SALTER

Salter IV

(T = Through both)

*

Nonaccidental Trauma

- Must consider child abuse with unexplained injuries
- Specific injury patterns
  - Transverse fracture through long bone
  - Metaphyseal corner fractures
  - Metacarpal/metatarsal fractures
  - Posterior/anterolateral rib fractures
  - Multiple fractures in various stages of healing

*

*

*

Summary

SALTER

(ABCDE'S)^2 in MSK Imaging

A = Anatomic appearance	A = Alignment, Asymmetry
B = Bone Density	B = Bone mineralization
C = Cartilage (joint, disk spaces)	C = Contours, Characteristics
D = Distribution	D = Deformity (trauma, acquired)
E = Erosions	E = Extent
S = Soft tissues	S = Swelling

ID CD
I dentify the abnormality (*Recognize* injury)
D efine the appearance (be descriptive)

C ategorize (when able); patterns, grades
D ifferential Diagnosis